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STUDIES ON THE TRANSFORMATIONS OF SATURNIAN MOTHS, WITH NOTES ON THE LIFE-HISTORY AND AFFINITIES OF BRAHMAEA JAPONICA.

By Alpheus S. Packard.

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This paper is the continuation of one presented to this Academy in February, 1893. It contains descriptions of the larval stages of some interesting genera of the family of silk-worm moths, Saturniidae, not hitherto known. Of these genera some are among the most highly specialized, while others are more primitive. It is a matter of some interest to have worked out the transformations of *Callosamia calleta*, an annectant form between Callosamia and Philosamia. The early stages of the species of Rothschildia, which represent in the New World the Asiatic Attacus, have now been discovered after several years of effort to secure the cocoons and eggs. We are now in a much better position than before to work out the phylogeny of the family and its relations to the Ceratocampidae.

Callosamia calleta.

A lot of 25 eggs kindly given me by the Sydney Ross Co., New York, through Mr. C. B. Riker, had hatched several hours before their receipt on June 6, from eggs laid May 21, 1903.

Egg. — Oval cylindrical, somewhat flattened; chalky white; the surface seen under a powerful lens to be minutely pitted. Length $2\frac{2}{3}$ mm.; breadth about $1\frac{3}{4}$ mm. The hole eaten by the larva for its exit is situated at the end of the shell, but sometimes encroaches on one side.

Larva. — *Stage I.* Length 6 mm. The body tapers slightly toward the end. The head is as in *P. cynthia*, being smaller than in *C. promethea*, and with no pale band; velvety black-brown; clypeus-posterior a little paler; clypeus-anterior pale gray or dull livid whitish; the head bears a few scattered black hairs. The body is blackish brown and all the setae are black-brown, being of the same hue all over the body.

The first thoracic segment bears six tubercles, of which the lowest one is a little larger than those of the row above, and the two median dorsal ones are slightly smaller than those on each side. They are well developed, higher than in *C. promethea*, and nearly as in *P. cynthia*. The tubercles of the three thoracic and 1st abdominal segments of the same size and height, those of abdominal segments 2–7 a little smaller; all are about twice as long as thick; the longer setae are fully twice as long as the tubercles bearing them; those on the 2d thoracic to 7th abdominal segments are a little curved. Each dorsal tubercle bears 10–11 setae, several arising some distance below the crown; all are of unequal length and thickness; those on the mid-abdominal segments 7–8 in number. The median dorsal tubercle on 8th abdominal segment is twice as thick and considerably higher than those next to it.

Suranal plate with two tubercles higher than broad; this and segments 9 and 10 and all the legs, both thoracic and abdominal, are brown-black.

The body is black-brown; all the segments are ivory white on the posterior edge (the 1st and 2d thoracic less so than those behind), and the front edge of the white transverse band makes two scallops on each side. Front edge of each segment dark, but the base of each tubercle is surrounded by white.

It moulted June 11, all the individuals casting their skins simultaneously, just as all were observed to hatch at the same or nearly the same moment.

Stage II. Length 11–13 mm. The body is rather thick and the thickness uniform. The head is not nearly so wide as the body. It is peculiar in shape and color, rather deeply bilobed; the surface soft velvety black-brown, apex of the clypeus pale greenish; between this triangular spot and the eyes is a deeper yellow roundish spot, and behind each group of ocelli is another long yellow mark; clypeus-anterior white, labrum black.

The body is armed with large, rather high tubercles, all nearly of the same size, though those of the 2d and 3d thoracic segments are very slightly larger than those on the abdominal ones, and that on the middle of the 8th abdominal segment is nearly twice as thick as those on the 7th segment.

On the prothoracic segment are four large high tubercles of equal size and height, but slightly smaller than those on the 2d and 3d thoracic segments, each with four stout spines and four smaller ones. All the tubercles are fleshy and stand up like columns, and are about twice as

high as thick. The median tubercle on the 8th abdominal segment bears twelve setae arranged six on each side of the crown; those on the 9th segment with four large setae.

Suranal plate with two large erect tubercles from a third to a half smaller than those on the 9th segment, and bearing five large, long, and five finer setae; farther back near the end are two small low tubercles bearing from two to three coarse, and two or three finer bristles. Anal legs with setiferous tubercles on the hind edge.

The body is uniformly deep ochreous yellow. The 1st thoracic segment is prussian or dark steel blue, but yellow on the hinder edge, with a yellow spot on the side, or the segment may be all yellow except around the base of the tubercles; the other segments are yellow. Suranal plate and anal legs of a rich dark steel blue. On the front edge of each segment (thoracic 2–3 and abdominal 1–8) there are three dorsal triangular black-brown spots which are usually connected by a black line along the suture; behind these spots on each segment is a similar black line dilating into three triangular spots which vary in being either connected or separate. Spiracles dark, on a dark ground. Both thoracic and abdominal legs black; under side of the body blackish.

In this stage the markings are much as in *C. promethea*, i. e. the two transverse black bands, but they are farther advanced or more specialized, and the head is without the transverse pale band in front; the prothoracic and other tubercles are the same. They are of the same general proportions, but in color *C. calleta* is darker, especially beneath, and on the suranal plate and legs *calleta* has longer bristles.

End of Stage II. When about to moult (May 26) it is 23 mm. in length. The head in my example was very small, and is just as described in Stage II, but with traces of another yellow spot. At this time the body is much less spotted and marked with black-brown. The 1st thoracic segment is ochre-yellow, with four irregular black spots along the hinder edge, while the area around the base of the four tubercles is blackish. All the tubercles are smaller in proportion to the body, but preserve the same proportion to each other as in the beginning of Stage II; the body being larger, the tubercles are wider apart.

Each segment behind the 1st thoracic with two series of three blackish triangular spots, the middle one in front triangular and longer than the lateral ones (as in the early part of the stage). The one corresponding to it on the hinder line (which is half-way between the dorsal tubercles and the hinder edge) is transversely linear; the spots vary in being either separate or connected; they are smallest on the 8th and 9th

abdominal segments. All the tubercles are uniformly dark prussian or steel blue. Suranal plate yellow, except the black subtriangular patch giving rise to the tubercles. Along the side below next to the base of the legs is a series of detached greenish yellow spots, the two on the 2d and 3d segments centred by a steel-blue minute tubercle, this being the fourth on each side. Abdominal legs dark, with a yellow spot at the base on the outside.

Stage III. Described May 29. Length 35 mm. The larva is in this stage a very different creature from what it was in the previous stages. It is now gorgeously colored, and a very conspicuous caterpillar. The ground color of the body is pea-green, while the large swollen base of each tubercle is deep reddish orange approaching vermilion, contrasting with the dark steel-blue of the spines surmounting the base.

The head is very small, not one-half as wide as the body, and one-third narrower than the 1st thoracic segment. The clypeus-posterior is now pale turquoise-blue, and there is a broad red-orange stripe on each side of the clypeus.

The three black spots on each segment are still large and conspicuous, while those on the hinder edge are minute. The centre of the suranal plate and of the anal legs is stained deep red-orange, as also the outside of the mid-abdominal legs. The thoracic legs are also painted with two vermilion-red rings.

There is the same proportion between the size of the dorsal tubercles.

The setae are scarcely as long as the spines themselves.

Stage IV. Length 38–40 mm. Differs but little from the previous stage in armature and coloration. In this stage most of the larvae have the tubercles entirely black; in a few, however, the dorsal ones on the 2d and 3d thoracic, 1st, 2d, 3d, and 8th and 9th abdominal segments are pale blue at the tips; and sometimes those on a less number of segments are tipped with blue. The six tubercles on the prothoracic segments are still well developed. The suranal plate is pale red; the sides of the anal legs deep bright red, as also are the ends of the mid-abdominal legs; the thoracic legs are black ringed with red.

Stage V. Length 65–70 mm. Head and body pea-green. Shape of the body nearly as in Philosamia, but the tubercles very much thicker and larger. Those on the 3d thoracic segment and 1st abdominal a little larger than the pair on the 2d thoracic segment. The dorsal abdominal tubercles somewhat unequal in size, those on segments 2–7 about one-half smaller than those on the 1st abdominal segment, those on segment 6 being a little smaller than the others. The median tubercle on

the 8th abdominal segment nearly three times as thick as that on the 6th segment. All the tubercles bright red on the swollen base; beyond, turquoise-blue; the short spinules black. Suranal plate, the side of the anal legs, and the thoracic legs yellow. Mid-abdominal legs yellow, black at base.

There are two subdorsal rows of black spots, one on each side; a black band on the front of each segment passes down to a point near the spiracles. The larvae vary in the amount of black on the body, some having more, others less.

The larva differs from Stage IV in the part of the tubercles above the red swollen base being much thicker, the spinules shorter, and there are no tubercles on the prothoracic segment, these being in the last stage represented by black dots.

The larva feeds on the wild cherry.

This is an unusually conspicuous larva, and as usual in the group the bright hues and spots may be regarded as warning colors, the insect being protected by what are probably venomous spines.

In its markings (the six dorsal black spots) and armature it closely resembles *Philosamia cynthia;* the tubercles are all large and of nearly equal size and shape as in the 2d stage of *P. cynthia.* There is no such inequality as is to be observed in the 3d stage of *C. promethea* where the 2d and 3d thoracic dorsal tubercles and that in the middle of the 8th abdominal segment are three times as large as all the other dorsal abdominal ones.

Judging by the larval characters *Philosamia cynthia* is a more primitive or generalized form than Callosamia, since Philosamia retains the equality in the size and shape of the tubercles all through its larval life.

C. calleta up to the end of Stage III is really nearer to Philosamia than the genus to which it is generally referred, and this suggests that phylogenetically Philosamia is the older genus, and that from it directly sprang the species of Callosamia; *C. calleta* being the oldest species.

Mode of casting its skin. — Before moulting the abdominal legs are folded together and the crown or rings of both are contracted.

One was seen in the act of ecdysis; the skin had split open at various places from one end of the body to the other. The thoracic legs become free or are drawn out of the old skin before the head is cast off.

Rothschildia jorulla.

(*Attacus cinctus.*)

Larva. — Beginning of Stage II. It was hatched in New York from a few eggs laid by examples bred from the cocoon and mated by Mr. Joutel, and sent me May 8, and described May 9. Length 7 mm. Body unusually short and thick, and now much wider than the head, which is of the usual shape (as in Telea and Philosamia), smooth, with long scattering irregular hairs; antennae white; it is black and yellowish-white, the sides black, with a black V on each side of the yellow clypeus-posterior; clypeus-anterior with a whitish transverse line.

Body and legs dull livid brownish. The tubercles are very large and crowded together; they are full, globular-conical, and a little higher than thick, and all pale straw-yellow.

There are four dorsal prothoracic tubercles, but the two on each side are united at base, making a large double transverse tubercle higher than any of those behind, and all four connected by a ridge; yet they are shorter than in Stage I.

All of the tubercles behind the prothoracic segment are of the same size and height, the meso- and the metathoracic ones not differing from each other, nor are the abdominal ones smaller than those on the thoracic segments, nor do they differ in height or size among themselves, except the median tubercle on the 8th abdominal segment, which is quite broad and one-fourth larger and higher than the others, and about twice as wide as the others; there are 6–7 setae on each side. Those on the sides of all the segments are of the same size.

The dorsal tubercles are each armed with eight stiff setae, which are pale brown, the longer ones of which are about a third longer than the tubercle itself, one being in the centre and the others arranged around it.

On May 17, after being forced by a sojourn in the kitchen, it was ready to moult; its length was 13 mm. The body had now become livid greenish-yellow; the tubercles all straw-yellow, and of the same proportions. The spiracles are dark, rather conspicuous. There is a transverse blackish line on the prothorax behind the four tubercles.

Stage III. It moulted May 18, and was described on the 19th. Length 20 mm. Head yellow, black behind, with a broad V in front connecting with the black base of the clypeus anterior. Body thick, head only one-half as wide as the body in the middle. First thoracic considerably narrower than the 2d thoracic segment. The tubercles are still all similar, of the same size and color. The two dorsal ones on each side

of the prothoracic shield still united. The median dorsal tubercle on the 8th abdominal segment is nearly twice as thick and somewhat higher than those on each side. Each dorsal tubercle bears 8 or 9 setae, while on each infraspiracular tubercle are from 8 to 12 setae or spinules.

The body is now black, the sutures between the segments white; the hinder edge of each segment, beginning with the 2d thoracic, also white. Suranal plate straw-yellow with an irregular longitudinal band, widening behind the two tubercles. The tubercles orange-yellow, straw-yellow at base. Anal legs entirely black. Thoracic legs and antennae pale at the end; abdominal legs all black. Spiracles black, surrounded by black. It moulted May 22–23.

Stage IV. Length 23 mm.; at end of the stage 35 mm. The body is now thick and stout, leaf-green. The head is pale straw-yellow, black behind, enclosing a distinct oblong black spot; clypeus broadly edged with black, making a V. Antennae and clypeus-anterior whitish.

The dorsal tubercles are all of the same size, and of the same orange color. The spines on those of the three thoracic and 1st abdominal segments somewhat dusky; those on the tubercles of the segments behind are all pale, while those on the infraspiracular tubercles are a little dusky, as also those of the two dorsal tubercles on the suranal plate. The plate is rather smooth, pale straw-yellow, and bearing along and just outside of the edge a hollow triangular black mark with the corners well rounded. Anal legs green, with a similar but larger hollow black subtriangular ring; the legs below and all the abdominal legs are black with a green spot on the outside of the middle, and bearing long white hairs of even length.

At the end of this stage, May 28–29, it was 35 mm. in length. Now the tubercles are all deep reddish from the top to the base, greatly contrasting with the deep green of the body. The lower edge of the 9th and 10th abdominal segments are now white, forming a broad line.

The front edge of abdominal segments 3 to 7 whitish. The green spot on the outside of the mid-abdominal legs is now yellow.

For a day after moulting it nibbled its cast skin.

It moulted for the fourth time about June 1, and was described June 3.

Stage V. Length 48–50 mm. Head and body deep pea-green, the head green, with two black lines behind, while the clypeus is lined with black. The head is still small in proportion to the body, being about one-third the width of the latter, and only two-thirds as wide as the prothoracic segment. The prothoracic shield is now smooth, with four

median minute groups of 4–5 minute short setae, and two rounded lateral small tubercles. The *tubercles of the 2d thoracic segment are smaller than those on the 3d, the latter not being so high and prominent* as those on the 1st abdominal segment; those on the thoracic segments are flattened, button-like, not so high as thick; all orange-yellow, and bearing from 4 to 7 short black stout setae, the longest ones no longer than the tubercle is high.

The *tubercles on abdominal segments* 2–7 are smaller *than those on the 1st abdominal segment,* and gradually become smaller towards the 7th segment. The setae in general are a little longer than the tubercles are high.

The median tubercle on the 8th segment is low, not so high as broad, and in outline seen from above is transversely oval, bearing 4 principal larger setae and three minute ones besides. (The originally double origin of the tubercle is not evident.)

There are on the 9th abdominal segment very minute green vestiges of two tubercles.

Suranal plate green, with a conspicuous white stripe on the edge, and on top of the plate is a subtriangular black mark made by a narrow black line, and a triangular black ring on the outside of the anal legs.

Front edge of abdominal segments 3–7 *with a broad, conspicuous pale purple-madder stripe, which is widest below and narrow above; this is succeeded by a white band, widening dorsally and conspicuous when seen from above.* Spiracles yellow ochre. Thoracic legs green, irregularly ringed with black, the tips black; the four pairs of mid-abdominal legs black-brown, with an external conspicuous yellowish-green patch, and armed with rather long curved setae. The plantae of the anal legs black-brown.

Cocoon. — On the morning of June 13 my larva, which was a little under the normal size, had begun to spin a cocoon, and the handle or stem of the cocoon had been spun before it was nearly finished; the rather large opening for the exit of the moth had been left open.

Number of moults and habits. — There are four castings of the skin and five stages, as usual in the bombycine moths, and the family Saturniidae. In captivity in a northern State (New York and afterwards Rhode Island), the ecdyses occurred at about every ten days, the eggs being laid near the end of April and the larvae hatching out the first of May.

Food plant. — The larvae were fed on the ash and wild cherry, but preferred the latter. Its native food-plant is unknown to us.

Rothschildia orizaba.

Larva. — Stage I. Hatched July 8–9. Described July 12, 1902.

Length 8–10 mm. Body cylindrical, rather slender, slightly more so than in *T. luna*. Segments not convex, more as in Callosamia than in Telea or Tropaea. Head rather small, rounded, much as in Callosamia, a little more than half as wide as the body in its thickest part; pale whitish, surface very finely granulated; edge of clypeus dark brown, and a transverse line across the front edge; a large brown round spot on each side.

Prothoracic segment with no definite plate, but with six long slender high greenish-yellow tubercles, about one-third as thick at base behind; six setae in each dorsal tubercle; the longer setae about twice as long as the tubercles. All the tubercles on the second thoracic segment to the end of the body much swollen at base, being conical, large, and pale straw-yellow, and *all of the same size and height*, but those of the 2d and 3d thoracic segments are fused together at their base, while those of the abdominal segments are distinctly separate.

The median tubercle of the 8th abdominal segment is only a little larger and a little broader than those on the 9th segment; those on 9th abdominal segment fused at base.

Body above black, except the thoracic segments, which are greenish, with two black spots on each segment above; the sutures livid greenish.

Suranal plate with two large, slender, distinct tubercles, about one-half as large as the supraspiracular one on the 9th segment; it is greenish yellow, but behind the tubercles dusky. Anal legs blackish in the middle. Infraspiracular row of tubercles arising from the lateral ridge pale greenish-livid, as is the under side of the body and the abdominal legs. Thoracic legs black.

Each tubercle with six dusky setae, the longer ones a little longer than the tubercle itself.

A very beautiful caterpillar, which resembles that of Callosamia in coloration, but the tubercles are larger, conical, and all alike in size.

Larva. — Last stage. Head rounded, about one-half as wide as the body is thick, and not so wide as the cervical plate; the surface of the head smooth, polished, with scattered fine hairs on the clypeal region and about the ocelli; in color pea-green. Body thick, cylindrical, tapering a little towards each end; how convex the segments are cannot be determined in blown examples. Cervical plate smooth, with no vestiges of tubercles. On the prothoracic segment below the edge of

the cervical plate is a slight vestige of a tubercle in front of but a little below the spiracle; farther down, near the base of the leg, is a decided but small low tubercle bearing three setiferous spinules; those in the same relative position on the 2d and 3d thoracic segments are of the same size and shape.

On each of the two hinder thoracic segments there are four small dorsal tubercles in a transverse row. Each tubercle is crowned by a ring of 5–6 spines, with one in the centre. These and the dorsal ones on abdominal segments 1–7 are so closely alike in size and armature that it is difficult to see any difference in size between the thoracic and abdominal dorsal ones. The four dorsal ones on each of the two last thoracic and the first seven abdominal segments are alike in size, number, and arrangement of the spinules; there not being the usual distinction which obtains in the Attacinae (Samia, Callosamia, Telea, etc.) between the submedian (dorsal) and supraspiracular series. Those of the 7th abdominal segment are, as far as I can see, just like those on the 2d and 3d thoracic and 1st abdominal segments.

The median spine on the 8th abdominal segment is scarcely higher (longer), but is about one-quarter thicker than the one on each side; it is slightly broader than long (seen in section from above) and bears five spinules on each side of the median line. There is no infraspiracular row of tubercles (such as are present in the Citheroniinae and Attacinae). There also seems to be no difference in color between any of the tubercles.

The suranal plate is green, a little rough on the surface, and there are traces along the hinder edge of piliferous spines; the plate is edged with black. The anal legs are large, green, the triangular area edged with black, and on the edge are scattered small black piliferous warts. The thoracic legs are pea-green; the abdominal legs green, with irregular rows of black warts bearing white hairs above the plantae, which are, with the hooks, black. Along the side of the body extends a broad lateral yellow infraspiracular line, from which and below which arise long fine white hairs. The spiracles are sienna brown-yellow. The body is covered with fine white short clavate hairs. Length 80 mm.

An inflated example from Mexico in the U. S. National Museum, collection of Dr. H. G. Dyar; two inflated examples, in bad condition, from Tacubaya, Mexico (Barrett).

In the species of this genus the degree of specialization of the tubercles in the larva is very slight, as they show a tendency to reduction and atrophy, which reaches its greatest perfection in *R. betis*, in which

there are, according to Burmeister's figure and description, no tubercles at all, while the body is blackish, with conspicuous transverse bands.

R. orizaba, as a larva, in form and markings most nearly approaches that of *R. aurota*, while the most generalized species is *R. speculifer*, in whose larva there are the longest tubercles, most nearly approximating those of Samia and Philosamia.

Food plant. — Specimens raised from the egg by Mr. Joutel fed on the white ash. Its native food plant is unknown to us.

Rothschildia jacobeae.

The materials on which our life-history of this species is based were obtained by the American Museum of Natural History from Buenos Ayres. It consisted of the eggs, inflated larvae in three stages, the pupa, cocoon, with the ♂ and ♀, all in an excellent state of preservation, and I am indebted to Dr. H. C. Bumpus, the Director of the Museum, and Mr. William Beutenmüller, the assistant in charge of the Department of Entomology, for the loan of the specimens.

Eggs. — Oval, flattened, chalky white; surface shining, seen under the lens to be very finely pitted; greatest diameter about 2 mm.

Larva. — *Stage II.* The blown larva in the 3d stage had retained on the last half of the body the skin of what we suppose to be of this stage. It shows, what is not present in the next stage, *two parallel rows of* 6 *linear black spots passing across the segments.* On the suranal plate, on each side, is *a low flattened green tubercle, bearing six dark spine-like setae.* There are faint traces of a reddish spot on the plate, and on the side of each anal leg. *All the tubercles black.* The median tubercle on the 8th abdominal segment slightly bilateral, bearing four setae on each side. Suranal plate with a yellow band on the edge.

Stage III. What is probably of this stage is a blown larva. Length of body 34 mm.; width of head 2.7 mm. Head pale yellowish brown (probably green in life), clypeal sutures black, and on each side is a black line extending from the eyes up to the centre of the vertex on each side.

Body green; cylindrical, with prominent tubercles as in the corresponding stage of other Attacine larvae. Prothoracic plate with four well-developed green tubercles, which are low, rounded, about half as large as those on the 2d thoracic segment, and each bearing six dark setae. Tubercles of the 2d and 3d thoracic segments each with fairly large green warts or tuberculets, each bearing a black seta longer than the main

tubercle, at least a third longer. Those of the 1st abdominal segment a little larger than those on segments 2–7.

The median tubercle on the 8th abdominal segment double, and apparently as large as the thoracic ones (this is covered by the loosened skin of the previous stage). Legs as in the last stage, but the mid-abdominal ones not so much black in extent at the end. Spiracles black. The yellowish rings of the later stage are in this period faint.

Stage next to the last. Length of body 70 mm.; width of head 4 mm. Head and body pea-green, as in the last stage. On the prothoracic segment the position of the primitive dorsal tubercles (seen in Stage III) is indicated by minute setiferous warts. Dorsal tubercles on the 2d and 3d thoracic segments a little (about one-fourth) larger than those on abdominal segments 1–7; those on the latter-named segments slightly larger than those on the intermediate segments, all bearing six radiating and a central erect black seta; the tubercles are pale green (in the blown larvæ examined they have turned yellowish like the dorsal ones).

The median tubercle on the 8th abdominal segment of the same size as those of the dorsal on the 2d thoracic segment; it shows a slight bilateral arrangement, there being six black setae on each side.

Suranal plate and each of the anal legs with a pale bright red spot as in the last stage. Spiracles black; legs as described in the last stage.

The larva in this stage differs from the full-grown caterpillar in the larger tubercles, all of which are armed with well-developed spine-like setae; in the nine (one more than in the last stage) yellow bands, there being an additional one on the 2d thoracic segment, the bands or incomplete rings beginning at the infraspiracular row of tubercles and passing over the back from one side to the other.

Last stage. Length of body 110 mm.; width of head 4½ mm. Body cylindrical. Head small rounded green, smooth, less than one-half as wide as the prothoracic segment; the clypeus narrowly edged with black, and two diverging black lines extending from near the centre of the vertex and passing down inside of the ocelli.

Prothoracic segment with no traces of dorsal tubercles, but a green pyriform tubercle in front of and a little below the spiracle, and a larger, more prominent one still lower down, bearing six short setae, five around the edge of the crown and one in the centre.

Dorsal tubercles small pyriform, present on the 2d and 3d thoracic segments; those on the 1st abdominal segment about a third smaller than the thoracic ones, and with no setae. On abdominal segments 2–7 the dorsal tubercles decrease in size to the 7th. The median tubercle on the

8th abdominal segment dark green, fully as large as the thoracic ones, and bearing five distinct peripheral and one central black seta (their stumps being present, probably broken off while being inflated; they are faintly seen in the penultimate stage). Tubercles of the supraspiracular row minute, smaller than the dorsal ones; those of the infraspiracular row larger, and still armed with 7–8 black setae. It differs from the larva of *R. orizaba* from Mexico in having no definite hairy lateral yellow ridge.

Suranal plate small, rounded behind, with a few small fine hairs and bearing a large central bright red rugose spot; the lower edge yellow; on the sides of the anal legs a little larger triangular spot of the same color. Spiracles black, very conspicuous. Segments smooth, and with a pale yellowish band or incomplete ring (8 in all) in front of each spiracle.

Thoracic legs pale, black at the end, 1st and the 3d joint entirely black. Mid-abdominal legs green, a yellow patch above the planta, broadly bordered with black, and the planta black.

Described, as are the other stages, from blown specimens.

It differs in this stage from the larva of *R. orizaba* in the abundant hair-like setae on the lateral ridge, and in the red spots on the suranal plate and side of the anal legs. In its armature it differs from that species.

Cocoon. — Oval, not much larger at one end than at the other; the stalk very slightly developed. Length 53 mm., thickness 21 mm.

Pupa. — Of the form of Cynthia, but not so thick; of the usual chestnut brown color. Length 28 mm., thickness 13 mm.

Rhodia fugax.

The eggs, received from Japan, were hatched April 27, and the larvae described on the 28th. It feeds on the poplar and dwarf willow.

Larva. — *Stage I.* Length 6 mm. Head large, wider than the body, with long scattered hairs; brown-black with a transverse whitish patch on the clypeus-anterior, while the base of the antennae is of the same color, so that across the front of the head extends a broken whitish inconspicuous line. The body, as usual in freshly hatched Saturnian larvae before the larva has taken food, tapers to the end.

The dorsal tubercles are distinct, a little longer (or higher) than thick, those on the thoracic segments larger than the abdominal ones; those on the prothoracic segment about half as large as those on the 2d thoracic

segment, which are very slightly larger and longer than those on the 3d thoracic segment. The prothoracic dorsal tubercles each bear four curved setae, while the 2d and 3d thoracic dorsal tubercles each carry six setae. The abdominal tubercles are nearly as long as the thoracic ones, but much slenderer, and they are rather high, contracting in diameter in the middle; they each bear 2 or 3 long curved black stiff bristles, and two minute ones, the long ones being curved backwards, and before the larva has begun to feed they are longer than the body is thick, so that it appears to be rather thickly clothed with fine black bristles.

The single median dorsal tubercle on the 8th abdominal segment is a third thicker than the others in front, bearing three long black setae on each side.

The two dorsal tubercles on the 9th abdominal segment are quite large, larger than those on abdominal segments 1–7. Two dorsal tubercles arise from near the middle on each side of the suranal plate; they are only a third smaller than those on the 9th segment; around the edge of the suranal plate arise long grayish stiff straight hairs, and the bristles on each lateral tubercle are grayish and directed downward.

The body is dull straw-yellow on the sides and black above. The wide black dorsal band is irregular in width, varying at the end of the stage.

It gives off on each side behind the middle a straight black rectangular line forming a black half-ring extending down to near the spiracles; the hinder edge of each segment is black. The color variations of the larva in this stage are marked; in the most extreme the entire upper part of the body is black below the spiracles, the black pigment extending down from the main mass to the infraspiracular tubercles, the under side only of the body being yellow. There is low down on the side of the body a narrow worn somewhat broken black line, situated below the infraspiracular tubercles. Spiracles small, inconspicuous, black. Thoracic legs black; abdominal legs in general yellow, when freshly hatched black, the planta slightly purplish livid. In this stage the larva is very pretty and interesting, but with the true Saturnian shape of body and tubercles. They moulted May 24 or 25.

Stage II. Length 12 mm.; toward end of stage 18 mm. Now very different from Stage I. The body is pale straw-yellow, and no black on it in my examples (while one of those reared by Mr. Joutel is black on the sides and on the 1st, 3d thoracic and 8th abdominal segments, and he found that there are all stages from the wholly yellow to the dark form).

The head is smooth, pale-green, black behind the eyes, the black extending up towards the back of the vertex; it is nearly as wide as the 1st thoracic segment, which is considerably narrower than the two following. The tubercles are now more prominent and are green and pale turquoise-blue. The four dorsal ones on the 1st thoracic segment are well developed and higher than before, the two middle ones nearly a quarter larger than the outer ones, each bearing six stiff straight black setae. The spiracular one is pale turquoise-blue, as all the others of this series to the end of the body. The two dorsal tubercles on the 2d and 3d thoracic segments considerably (about one-sixth) larger than those on the abdominal segments and those on the 3d thoracic considerably larger than those on the 2d segment; they each bear eight black stiff setae, seven on the crown with an eighth in the centre; these are yellowish at base, beyond turquoise-blue; in the examples I bred the tubercles on the 2d thoracic segment were green. The setae on the thoracic tubercles are not more than a quarter larger than the tubercle itself. All the dorsal abdominal tubercles are green (or yellowish green, Joutel), bearing each four black stiff and straight setae, one of them being usually small; the longest setae are about one-third longer than the tubercle itself. The dorso-median tubercle on the 8th abdominal segment, unlike all the other abdominal ones, is turquoise-blue; it is fully twice as thick as those on the 7th segment. It does not show its double origin as there is a central seta, and one behind it on the median line, with three on each side of the two; they are not arranged on each side of the median line.

On the side low down are two or three minute black dots below each of the turquoise-blue tubercles of the lowest series.

Suranal plate and its tubercles pale straw-yellow, concolorous with the rest of the body, with a large black roundish spot in the centre. In those reared by Mr. Joutel, the two tubercles on this plate are turquoise-blue. Spiracles black, fairly conspicuous. Anal legs green, centred on the outside by a rather large and conspicuous black spot; the mid-abdominal legs are green or yellowish green; thoracic legs black.

On June 2d the larva had become 18 mm. in length, otherwise it did not differ from its appearance directly after hatching.

Mr. Joutel's figures illustrate the wide colorational differences exhibited in the same brood of caterpillars. Some represent an entirely yellow individual, except the eleven turquoise dorsal tubercles, and those of the infraspiracular row; and the black lateral line, which is wanting in some of his specimens and mine. He found all variations between these and the very dark larva. In the 2d stage of the larva the body and tubercles

are black, with the exception of the yellow dorsal portion of the 2d thoracic and abdominal segments 1–7, and the under side of the body, including the mid-abdominal legs. He tells me that other specimens have as much black pigment on the body, but that the dorsal tubercles on the 2d and 3d thoracic and 8th abdominal segments are as blue as in the light-colored caterpillars.

The larva I had in Providence moulted for the second time about June 4 or 5.

Stage III. Length 20 mm. The head is now wholly pea-green. The two median prothoracic, and the two dorsal tubercles on the 3d thoracic segment, and those of the lateral row are turquoise-blue, but the two dorsal tubercles on the 2d thoracic segment are greenish. The two 3d thoracic dorsal tubercles are thicker than those on the 2d thoracic segment, and about twice as thick as those on the 1st abdominal segment. The medio-dorsal tubercle on the 8th abdominal segment is much thicker than those near it. The proportionate size of all the dorsal tubercles is as in the previous stage. Spiracles pale brown, not conspicuous.

The black dots low down below the lateral ridge are now nearly obsolete.

Anal legs with no external black spots, and entirely green. The thoracic legs green, with a few black spots.

Mr. Joutel, who had more larvae under inspection than I, says, "All the larvae are gradually losing the black pigment; the dark ones have only the base of the dorsal tubercles on the 3d thoracic and 8th abdominal segments black, with the tips blue; also the lower half of the face is black."

It was found to have moulted for the third time June 23.

Stage IV. Length 23 mm. (when underfed) – 42 mm. The body is now thicker at the 3d thoracic segment, and in fact somewhat so throughout, while the tubercles are smaller, and all but those on the back of the 3d thoracic and 8th abdominal segments are decidedly reduced in size. *The skin is now covered with minute rounded warts or granulations.* The head and body are pale greenish straw-yellow (more yellow than green). The tubercles are of the same hue as in Stage III. The six tubercles on the front edge of the 1st thoracic segment are turquoise-blue.

The two dorsal ones on the 3d thoracic segment are turquoise-blue. The medio-dorsal one on the 8th abdominal segment, and the four on the side of the 9th segment are turquoise-blue, but the two dorsal ones are

yellowish, of the same hue as the skin. The lateral series of tubercles are turquoise-blue, as before. On all the tubercles the setae are black, and shorter than the tubercles themselves are high.

The two dorsal tubercles on the front edge of the 1st or prothoracic segment are as large as those on the 2d thoracic segment, *while those on the 3d thoracic segment are nearly twice as high as thick*, also slightly smaller than in Stage III. Each bears six black setae, and an odd 7th bristle in the centre. The setae are not quite so long as the tubercles are thick.

The dorsal tubercles on abdominal segments 1–7 are now small, slender, scarcely half as high as the two on the 3d thoracic segment, and evidently undergoing reduction; each bears three setae of unequal length, two of which are short, and one generally longer, though they vary in length, the longest one being about as long as the tubercle is high. There are six setae on the medio-dorsal tubercle of the 8th abdominal segment.

Suranal plate with a rather stout turquoise-blue tubercle on each side near the middle, each bearing seven short black setae; end of the plate armed with five small setiferous tubercles, and an irregular row of black setae on the edge of the anal legs.

The tubercles of the supraspiracular row are minute, yellowish, and not quite twice as long as thick.

In the few reared by Mr. Joutel the larvæ were all alike, no matter what their color was in the previous stages.

Stage V. and last. Unfortunately my single larva died before assuming its final stage of growth, and I shall have to depend on Mr. Joutel's drawing for the following description. Up to this stage the caterpillar was in all its stages a remarkably striking and exquisitely beautiful one, especially in Stages III and IV, where the tubercles were of such a soft and delicate turquoise-blue, contrasting so markedly with the yellow or green hues of the body.

Length, when at rest, head down, 63 mm.; when extended in the act of walking, 78 mm. The body is now thick and fleshy, destitute of tubercles with the exception of the two medio-dorsal ones on the 3d thoracic segment, and the medio-dorsal one on the 8th abdominal segment, otherwise the body is entirely unarmed, with apparently no traces of the tubercles present in the previous stages. The tubercles on the 3d thoracic segments are (united into one), stout conical, nearly twice as high as thick at the base, and with a conspicuous dark spot in front. When at rest, head down, this horn projects up in a very conspicuous way. The

posterior tubercle (medio-dorsal) is small, low, button-like, not conspicuous; on neither of the tubercles are there any setae.

The body is now greenish yellow, with the sutures bathed with yellow. The lateral ridge is also yellowish, and along this ridge is a series of small blackish spots, one to each thoracic and abdominal segment, there being one on the side of the suranal plate. The head, all the legs, both thoracic and abdominal legs, and the under side of the body are pea-green.

Such differences between the last and the preceding stages as are seen in this caterpillar are very unusual. It is evident that the tubercles and bristles were undergoing reduction in the 4th stage, but one was hardly prepared for the loss, without apparent vestiges, in the last ecdysis, of all except the dorsal ones on two of the segments. The cause, if it could ever be explained, would be most interesting.

This case reminds us of a member of the same family, *Rothschildia betis*, but in that form all the tubercles are atrophied, and the change from the penultimate to the last is otherwise probably slight. A more striking resemblance is that to the larva of *Cercophana frauenfeldi* of Chili, of which there is a colored drawing in the British Museum. In this case the 3d thoracic segment is prolonged into a long curved fleshy horn which projects over the head when the latter is retracted. It has no tubercles, and a yellowish stripe extends from the tip of the horn along the side of the body to the end of the acutely prolonged suranal plate.

Its resemblance to the last (4th) stage of *Aglia tau* should also be noticed, though the latter at its final moult discards every trace of the armature of its earlier stages. This larva has what Poulton believes to be a terrifying spot on the side of the 1st abdominal segment. The question arises whether the spot on the front of the thoracic tubercles of *Rhodia fugax* is of this psychological nature, and also whether the dark patch on the front of the body under the horn of Cercophana is deterrent to other animals. All three of these larvae have a conspicuous yellowish or (on Aglia) reddish lateral stripe.

Sound produced by the larva. — Mr. Joutel informs me that this larva in its last stage "makes a squeaking noise by moving its head up and down on the prothorax."

Caligula japonica.

A large number of the eggs of this species were received through the kindness of Prof. C. Sasaki of the Agricultural College, Imperial Uni-

versity, at Tokio. They began to hatch March 31. Many of the eggs contained Pteromalid parasites in the pupa state; these emerged at the same time as the larvae, and probably stung them, since they all died before completing their transformations, though several moulted five, and one six times.

It being too early for the natural food, which Professor Sasaki informs me is the chestnut (though the buds were given them), they ate sparingly at first of willow buds, and afterwards the leaves, so that after Stage II the larvae were apparently undersized, and the measurements here given will probably not apply to those raised in the air in their native country.

Egg. — Cylindrical, more so than usual; each end obtuse and well rounded; the shell is of a peculiar dull whitish-gray hue, irregularly mottled with blackish. The surface is seen under a strong lens to be finely pitted. Length 2 mm.; diameter 1 mm. The hole eaten by the larva for its exit is situated at the extreme end.

Larva. — Stage I. Length when hatched 5–6 mm.; width of head 1.01 mm. The head is nearly as wide as the body, jet black. The larva is of the usual Saturnian type, and appears much as in that of Telea and Tropaea; the body cylindrical, rather thick, though a little slenderer than in Telea, etc., and with two separate dorsal tubercles; and is armed with large tubercles, which give rise to radiating dark setae. The tubercles are black like the body.

On March 31 all were black, but on the next day (April 1) in three examples the tubercles were livid white, as also the mid-abdominal legs; while the hairs on the back from the dorsal and supraspiracular tubercles are black, those on the side of the body are pale. Yet these individuals had not freshly hatched, as there were no egg-shells in the box with them.

The tubercles and their size relative to the body much as in other Attacine larvae in their first stage; they are high, well developed. Those of the tergum of the prothoracic segment are minute, arising from a pale plate or area, and are about a fifth to a quarter as large as those on the segments behind. On thoracic segments 2 and 3 and on the abdominal segments all the tubercles of the two dorsal rows are a little higher than thick, giving rise to 8–9 dark radiating unequal hairs, one or two of which are longer, sometimes nearly twice as long as the others; they are on the average about one-half as long as the body is thick. They are minutely barbed, the barbs being short. The two dorsal tubercles on the 8th abdominal segment are no higher than those in front, all

being of uniform height. There are hairs on the supraspiracular tubercles.

At the end of this stage (April 16–17) the larvae became 8–12 mm. in length, though the head is no larger than at first.

The body is livid brown-black, but paler on the under side, almost glaucous-green, with a yellowish tinge, so that the lateral or pleural fleshy ridge becomes *a faint greenish-yellow line.* The tubercles are jet-black, and the hairs black, with gray ones intermixed.

Other examples before moulting have a pale dull whitish band extending across the labral region of the head, and *a lateral row of livid pale whitish spots.*

Stage II. Moulted April 16–17. Length of body 11–12 mm., width of head 1 mm., about twice as great as before. Directly after moulting the head, legs, and tubercles are *all* white. The lateral broken line or series of pale greenish-yellow lateral linear spots is *much more* distinct than before, being now conspicuous, while the body is dull livid blackish. Now there are *scattered over the body long white hairs, and similar ones form the central one or two setae in each tubercle;* they are about one-third as long as the whole body, but in the lateral or infraspiracular row of tubercles all the radiating hairs are long and whitish. The white hairs are most abundant on the prothoracic plate and head. The short hairs on the body are still black. Under side of the body livid.

Stage III. Moulted the second time May 1. Length 24 mm.; head larger, width 2.5 mm.

The most decided change is in the prothoracic hairs and those on the sides of the body, which are straw-yellow, while the anal legs are edged with straw-yellow. The longest dorsal hairs are about a quarter to a third as long as the entire body. The body is still rather long and slender, and much more hairy than in the larva of Antheraea. The tubercles are still more prominent, black, the ends and the tuberculets livid. The hairs are long, not stiff, but a little crinkled, and they partially conceal the tubercles. The latter are still all of the same size.

Stage IV. Third moult occurred May 17–20.

Length of body 22 mm.; width of head 3 mm.

There is now a decided change in coloration and markings. The head is nearly as wide as the body, black, the clypeus-anterior white; labrum yellowish; the head armed with long uneven yellow hairs.

The body is still only moderately thick, and is long and slender, not at all like Antheraea in shape; the segments are not convex, but flat,

and of the same thickness to the end of the body, but the anal legs are large and triangular.

The tubercles are larger and more prominent than before, and very conspicuous, as they are white or yellowish white. The prothoracic plate bears long hairs, and on this segment there are no decided dorsal tubercles, the vestiges being low and flattened, while the lateral ones are fairly prominent and black.

The 2d and 3d dorsal thoracic tubercles are no larger than the abdominal ones; those of the 3d thoracic segment a little larger, however, than those on the 2d thoracic segment; and those on the 6th abdominal segment a little larger than those on the 7th and 8th segments (one on the 6th is larger than its mate).

The two dorsal tubercles on the 8th abdominal segment are separate, like the others, and show no signs of coalescence; they are slightly larger than those on the 9th segment, which are also separate.

Each dorsal tubercle gives rise to about four radiating stout, sharp, slightly dusky setae, while from the centre rises a very long yellow hair, or more often two or three, usually three such hairs; the skin between the tubercles bears on the top and sides of the body long fine white hairs. The longest yellow hairs are about one-third longer than the body is thick. The area around the base of the tubercles is white, due to crowded flattened snow-white warts, which are crowded around the base of the tubercles and scattered between so that the dorsal region is white, though interrupted; the sides of the body are black, enclosing the dull livid spiracles. The oval flattened tubercles are scattered along just above the pleural swollen yellow line and beneath on the under side, where they become straw-yellow. The tubercles of the 9th abdominal segment bear setae which are mostly black or dark. The tubercles of the supraspiracular row are prominent, but small, pale, and bear 8–9 short pale setae, with a very long yellow one (sometimes two) arising from the centre. Those of the infraspiracular row are about twice as large as those of the supraspiracular series, and bear about nine setae arising from prominent warts, while the setae assume the shape of long uneven yellow hairs.

The thoracic legs are black; the mid-abdominal ones pale greenish-yellow with the plantae reddish; anal legs large, broad, triangular, black, spotted in the centre with yellow and with yellow hairs around the edge, but none arising from the central portion. Suranal plate broad, triangular, a little shorter than broad, roundish at the end, with setiferous white warts, the hairs around the edges yellow; two groups of 7–8 setae, one

on each side near the edge, arising from distinct warts; each group, representing a primitive tubercle, is situated a little nearer the base of the plate than the end.

The setae on the supraspiracular tubercles of the 8th abdominal segment are also dark.

In this stage it is a rather conspicuous larva, and a very beautiful one.

Stage V. It moulted again June 3. It is now a most beautiful larva.

Length of body 35–40 mm. Width of the head 4–4½ mm.

Head nearly as wide as the prothoracic segment, greenish straw-yellow, spotted with brown, the sides brown; a V-shaped dark line in front, each side of the clypeus being black.

The body of a beautiful tint of pearly greenish-white; the top of the body being broad, uniformly flattened, the sutures between the segments being shallow. The tubercles are distinct, but of uniform size, and about as high as thick, bearing seven rather stiff setae, one rising from the centre; the setae of the lateral tubercles are twice as long as the dorsal ones. Behind the tubercles each segment is crossed by two transverse impressed lines. On the 9th abdominal segment a few of the radiating setae are blackish or entirely black.

The body is very hairy for a Saturnian, being clothed with long pale whitish-yellow uneven hairs, the longest nearly twice as long as the body is thick; those on the side of the body bright straw-yellow. The lateral ridge and the tubercles of the two lateral rows are straw-yellow. Around the base of each infraspiracular tubercle is a reddish ring.

The spiracles are large, conspicuous, of a rich delicate turquoise-blue. Around each spiracle are several irregular small linear black spots and streaks, which are directed more or less upward and broken up into dots. The thoracic segments are black on the sides low down and on the under side. The separate warts on the sides of the body and on the outer sides of the mid-abdominal legs are rather large.

The suranal plate is rounded, as in the earlier stages, and with the anal legs spotted with black, and clothed with short curly pale yellow hairs.

Thoracic legs brownish; mid-abdominal legs yellow ochre, like the under side of the body, but above the planta greenish-yellow.

Stage VI. It moulted for the fifth time June 12–13.

Length of body 40 mm.; width of the head 4½–5mm.

The head is now entirely black, except the base of the labrum. The sides of the body (what before was straw-yellow) are now *all black, this*

tint extending far above the blue spiracles. The upper edge of this black region is irregularly dotted with white; the under side of the body is also black.

The top and middle of the prothoracic plate is white, divided into two halves by the median line. *The dorsal or upper side of all the segments to the end of the 8th abdominal segment is cream-white.* The tubercles are also greenish-white; each bear 6–7 long setae and one or two central ones, which are greenish and as long as the body is thick.

The suranal plate and anal legs greenish-yellow, with black dots and streaks. Thoracic legs chestnut brown: mid-abdominal legs dark green with dark plantae. Mr. Joutel tells me that some of his larvae had an extra stage.

Antheraea yama-mai.

I am indebted to Professor Sasaki for the eggs, which hatched at the end of March.

Larva. — Stage I. Freshly hatched. Length 6 mm. Head large, chestnut red. Body thick, of the general saturnian shape of the larva of Telea, etc., at the same age. Body straw-yellow, with a narrow black and a lateral or subdorsal black stripe, the latter a little narrower than the dorsal stripe; this dorsal stripe stops at the median tubercle on the 8th abdominal segment, while behind this tubercle is a transverse black line or suture between the 8th and 9th segments.

The setae or hairs are at first brown, very soon becoming black, but the tubercles at first are all yellow; afterwards they begin to turn black at the base, the ends remaining yellow; at the end of the stage they all become black. Thus, when from 24 to 36 hours old, the two dorsal tubercles on the 3d thoracic tubercle become black, as also the median one on the 8th abdominal segment. There is also a black triangular patch on the suranal plate, and one on the side of each anal leg.

The tubercles of the 2d and 3d thoracic segments are very large and conical; the median tubercle of the 8th abdominal segment is double, high; the two dorsal ones on the 9th segment are high, and the supraspiracular tubercles are prominent.

In the freshly hatched larva the black dorsal or heart line is heavier and more distinct than in the larva at the end of this stage.

Cervical plate of the prothoracic segment gamboge-yellow, the front edge around each submedian tubercle whitish.

The hairs above are brown-black, while low down on the sides of the body, on the head and prothorax, they are whitish.

The dorsal setae are rather stout, with slightly marked short spinules, while the setae of the lateral tubercules (supraspiracular and infraspiracular series) are slenderer, with longer delicate spinules, and longer than in *Telea polyphemus*, Stage I, being about three times as long as the tubercle itself.

Brahmaea japonica Butler.

A number of pupae from Japan of this interesting monogeneric type were obtained by purchase, and Mr. Joutel kindly mated the moths, thus obtaining a supply of the eggs, from which the larvae were reared by him and myself in all stages. The eggs were laid in April, and the larvae hatched April 27, while I received them alive (four examples) April 28. They fed on the privet and lilac, and throve well in Providence on the latter plant.

Eggs. — Rather high, somewhat conical, with a broad, flattened base and the apex a little depressed. It thus differs from the somewhat flattened eggs of Ceratocampidae, and from the ovo-cylindrical eggs of the Saturniidae; apparently presenting striking family differences. The shell is seen under a strong lens to be finely pitted.

Larva. — *Stage I.* Length 9–12 mm. Width of head 1½ mm. Head small, no wider than the body, smooth, jet-black, polished and shining; with scattered long hairs. Body elongated, rather slender compared with Ceratocampid larvae of this stage; the body does not taper behind. On the trunk segments (thoracic and abdominal) are six rows of small black tubercles scarcely higher than they are thick, and giving rise to from 7 to 8 black hairs about as long as one-third the diameter of the body. The tubercles on the 1st thoracic segment are no larger than those on the abdominal segments; on this segment they are situated on a black cervical shield, forming a transverse black band, somewhat contracted in the middle.

Four large, long, thoracic dorsal horns, all of equal length, a pair on the 2d, and another pair on the 3d thoracic segment. They are each about one-fifth to one-quarter as long as the body, all of the same shape and thickness, scarcely tapering to the end, which is blunt, black-brownish at the end, flexible, not stiff, rigid and chitinous, and furnished with numerous long fine hairs, which are of nearly equal length; those at the end almost forming a pencil or brush; each hair very finely spinulated.

The horns themselves are of uniform width, not varying in diameter, and with a twisted appearance, as in Stages II. to IV.

A large erect caudal horn on the 8th abdominal segment, a little stouter and not quite so long as the thoracic ones, but like them thin-skinned, hairy, not tuberculated or twisted as in the penultimate stage.

The dorsal tubercles on the 9th abdominal segments are of the same size and shape as those of segments 1–7.

Suranal plate small, triangular, black.

On each side of the base of the plate are two high erect horns, like those on the 2d and 3d thoracic segments, but about one-half as long, though of the same shape, thin-skinned, flexible, and with similar black hairs.

The spiracles are black and inconspicuous.

Coloration: The body is dull black, except the thoracic segments and end of the body. The thoracic segments are livid yellow, with black patches on the sides; in some individuals the first thoracic segment is black, with a small yellow spot above. There are two dark roundish dorsal spots on the hinder edge of the 2d and 3d thoracic segments. Along the body is a faint yellowish spot (sometimes reddish or rusty yellow) on each side above the legs. The 8th and 9th abdominal segments are pale ochreous yellow; the base of the caudal horn and suranal horns black.

The distinctive colorational feature is the pale steel-blue ring or band passing around the body in the middle of each segment and the dark sutures, making about thirteen bluish rings in all. Of these dark bands, that on the 1st abdominal segment is the widest, the corresponding ones behind, known by enclosing the spiracles, being a little narrower. The narrow bands are on the sutures between the segments.

The thoracic and abdominal legs are dark, except the front of the anal legs, which is yellowish.

In this stage the caterpillar is a very conspicuously marked and colored one, with a formidable armature in appearance, but the high slender horns are not stiff and spiny, only hairy. It remains to be seen whether this caterpillar is inedible by reason of some poisonous or nauseous secretion.

The larvae at Providence moulted May 8 or 9, having been in Stage I about 10–11 days.

Stage II. Length 12–15 mm. Width of head 1⅛ mm. It does not now much differ in the general proportions and length of the horns from the previous stage, though these are now *hairless and twisted* and some-

what longer, *but the body is now of a porcelain white, and the bands, now brown-black, are broken up into black spots.* All the horns are now longer, smooth, without the hairs of Stage I, while they appear as if slightly twisted, being enlarged at irregular intervals and there giving off a minute seta. The head is still black; there are two white longitudinal bands, quite irregular in length and width, on each side of the head. The antennae are black and the region around their base is black. The clypeus-posterior is black with two yellow spots in the centre. The labrum and the region on each side is black. The head is fully as wide as the body.

First thoracic segment straw-yellow, with four dorsal black spots whitish in the middle above; two black spots on each side. On the 2d thoracic segment are two larger black spots, and two larger ones on the 3d segment. On each of abdominal segments 1–7 are five black dorsal spots, the black bands now being divided into spots; on segments 8 and 9 two dorsal black spots, and the front edge is black. The 8th segment is orange-reddish, becoming deeper on the sides. The sides of the abdominal segments below the spiracles are orange-ochre, on the thoracic segments the corresponding region is yellowish. On the 9th segment are two dorsal black spots, and on the front edge five black spots.

Suranal plate pale straw-yellow, black at the end; there are two small black dots on the front edge. Each abdominal segment with eight black spots on each side of the median spot, making seventeen spots in all.

Anal legs white, with five black unequal vertical stripes, the edge of each stripe black all around. Mid-abdominal legs dark brown, with a black ring at base, and another just above the planta.

The skin is provided with very fine short scattered dark hairs, those on the mid-abdominal legs much longer than those on the body.

Stage III. Length 17–27 mm. Width of head 2⅔ mm. The head is mostly black, but with white lines so disposed as to break it up into five irregular black lines or spots on a side; the two on the vertex, one on each side of the median line or suture of the head, above the apex of the clypeus, each forming a short curved band; the two lowest black spots down on the side near the ocelli are triangular. Clypeus black, the head being white on each side next to it. The anterior division of the clypeus is white, as also the base of the antennae. Toward the end of the stage the white lines of the head become wider, so that the black areas are somewhat reduced in size.

The body is pearly white, with a larger portion white, the black spots being smaller and more numerous than in Stage II.

Prothoracic segment with only two dorsal spots instead of the four black spots of Stage II, the two dorsal ones conspicuous and elongated, diverging from each other.

The 2d and 3d thoracic and 8th abdominal segments, and the suranal plate at the base of the two horns, are now distinctly enlarged or swollen, remaining so through Stage IV, when they are more conspicuously inflated, much as in *Arsenura xanthopus* as figured by Peters. All the horns are much as in Stage II, being swollen where a seta is given off, and more or less crumpled, kinky, or twisted. Length of thoracic horns 10 mm., being fully one-half as long as the entire body; length of caudal horn 6 mm.; of the two suranal horns $3\frac{1}{2}$ mm.

The black patches more numerous and smaller; those on the tergum are now broken up into separate spots. There are now on each abdominal segment 1–7 three rows of lateral black spots, and a conical one just behind the middle of each segment, or seventeen spots on each segment. Of these three rows the lowest one is the spiracular one, the black spiracle being situated in the centre of the middle one of the three spots forming the line.

On the 8th abdominal segment are four black spots on each side, one enclosing the spiracle, and a median one behind the caudal horn. On the 9th segment are six black spots on each side and one in the middle, or thirteen in all. On the front edge of the 2d and 3d thoracic segments are two black spots.

The suranal plate is smooth, white, unarmed, no setae, only the two black horns; the end of the plate is black.

There is a group of about a dozen minute short fine setae on each side of the tergum of abdominal segments 1–7, marking the probable site of tubercles in the ancestors of the group.

Above each mid-abdominal leg is a black spot, while the legs themselves are blackish at base and near the planta, the basal spot enclosing a white patch; the hinder part of the leg is marked with obscure greenish yellow. Anal legs black, enclosing three unequal vertical white stripes. Thoracic legs black.

Under side of the body livid pale, with a wide black lateral and a black middle line.

This description will almost equally well apply to Stage IV, the two stages being much alike in coloration and armature.

Stage IV. Described May 16. The length of this stage was 4–5 days. Length 42 mm.; width of head $2\frac{3}{8}$ mm.

The body is now still long and slender, and of the same width through-

out. On the dorsal side it is of a shining bluish white with a yellow tinge. Four black dorsal dots on the prothoracic segment arranged in a square, and two larger black spots in front of each pair of horns; on each abdominal segment three or four minute dorsal black dots. On the side of each segment are 7–8 black spots which are arranged in two rows, one (containing the larger number of spots) straight, including the black spiracles, the other broken up into an oblique row of about three spots on one side of each segment and passing up the front edge of each segment. Further down on each side is a large black spot over the base of each mid-abdominal leg.

The head is striped with black, with five irregular unequal short black lines on each side, while there are two black patches next to the antennae.

The horns are now long and slender, a little tapering, but blunt at the tips; those of the 3d a little longer than those of the 2d thoracic segment, and between a third and a half as long as the body; the caudal horn is about one-fourth as long as the body, while those of the pair on the 9th segment are slightly more than half as long as the caudal one. The horns are all more decidedly curled or twisted than before, and the fine spinules more developed.

On abdominal segments 1–7, in the place where tubercles should be, is a group of ten minute very short somewhat scattered setae, indicating that they may be the vestigial remains of a tubercle; there are two similar groups on the 9th abdominal segment, of six similar fine setae.

End of the suranal plate black; the surface smooth, not finely tuberculated.

Under side of the body pale greenish, with a median interrupted black line, and on each side higher up is a heavier black stripe, more or less undulating, and on the abdominal leg-bearing segments they are slightly oblique, ascending toward and reaching the front edge of the segment.

It moulted about May 20–21.

It is noteworthy, that on the front edge of the prothoracic segment there are six vestigial tubercles, indicating the descent of this genus from ancestors with six tubercles. The two dorsal ones form a very small, nearly obsolete, slightly marked transverse rough area; but in front of the spiracle is a large low rough slightly raised round area with very short fine setae; below, above the base of the legs, is a more prominent brown one. The corresponding ones on the 2d and 3d thoracic segments are still less marked, being only faintly visible.

Stage V. Length 63–76 mm., width of head 6⅔ mm. *The body is now without horns, and is smooth*, cylindrical, a little flattened and

naked, with *minute tubercles in place of the horns*. The head is flattened in front, a little angular on the sides; the surface rough and straw-yellow, with five black lines of uneven width and length, a black band ending on the eye-area, there being in all eight lines and spots. Clypeus whitish, with two semicircular cross bands. There is a whitish patch in the middle of the vertex, and a whitish area on the sides.

The body is less cylindrical than in the previous stages, being a little flattened, and has the general appearance of a hornless Sphingid caterpillar.

The ground color is a delicate greenish pearly or porcelain white, bathed on each side of each segment and along the hinder edge of each segment with pale straw-yellow. On the smooth prothoracic segment are four black dorsal spots, two round ones in front, and two large ones behind; a lateral long stripe behind the spiracle. There are no marked dorsal spots; those of the oblique lines are minute, and the black marks are chiefly confined to the spiracular series.

On the 2d thoracic segment in place of the two horns are two low, rather large fleshy tubercles which are a little larger but not so high and prominent as those on the 3d thoracic segment, though the two latter are less broad at the base.

On the 8th abdominal segment, in place of the atrophied caudal horn, is a low inconspicuous tubercle, at the apex of which is an indistinctly double (?) little wart.

On the 9th segment are two slightly full, low swellings with seven or eight short minute setae, indicating that they were the site in the ancestral form of this genus of two horns, warts, or tubercles.

Suranal plate black at the end, which is somewhat rugose. Surface of plate whitish; on the sides and behind pale straw-yellow. On the site of the two horns of the previous stages are two rounded conical black tubercles which are more solid and chitinous than those in front, and more like vestigial horns.

On the side of the segments is a black spiracular very irregular and much broken line, the spiracles being black; above this line on each segment are three black spots forming an oblique line, the most anterior spot (forming the upper end of the line) being near the front edge of each segment. On each abdominal segment except the 10th (suranal plate) are two black dots situated near the front edge of the segment. Below the spiracular line the body is deeper, almost orange-yellow.

Thoracic legs pale, with black wings and spots, mid-abdominal legs dull livid green with a black narrow wing at the base, and another one above the planta.

Under side of the body deep salmon red, with an irregular black line on each side, and on this line and in towards the middle of each segment are small setiferous black tubercles, white at the apex, and giving rise to a very short seta. Anal legs fairly large, and sphingiform.

Habits. — The larva is active in its movements; when rudely poked or handled it will suddenly jerk its head as if offended, and eructate a portion of its partially digested food. It assumes a decided sphinx-like attitude.

Its larval life extends over about five or six weeks or 35–45 days. It moults four times; the first stage occupies about 9 or 10 days, the second about 6 or 7; the third and fourth stages about 4 or 5 days; and it remains in the last stage about a week (7–9 days); the eggs hatched May 27, and one larva pupated June 11–12.

Acceleration of characters after Stage I. — It is to be observed that the armature and coloration are the same in Stages II–IV. It is a rule in Ceratocampidae and Saturniidae that the characters of the last stage are not assumed until after the 2d moult, but here those of the penultimate stage are assumed after the first moult, and in Stage IV there is no sign of the atrophy of horns, and of the color differences of Stage V.

The larva malodorous and its colors warning. — Larvae of the last stage on being handled were observed to emit a peculiar strong odor, a little like musk, and it did so on several occasions when disturbed or handled.

This fact, that the larva throws off a bad smelling or repugnatorial odor, and that it also vomits its food on being disturbed, should be coupled with the fact that it is a conspicuously marked caterpillar in all stages of existence, both when ornamented with long horns at each end of the body, and when after its last moult it is smooth-bodied, without even a caudal horn. The caudal horn of the earlier stages shows no sign of a bituberculous origin.

Analogies to Ceratocampidae, and to Sphingidae. — On a first glance at the moth, one would naturally suppose that it had no relationship to either of these two families; the shape and peculiar markings of the wings are so unlike any of them, but a knowledge of the early larval stages, and of the pupa, with its subterranean habits, led us to examine its structures and affinities, and at first we supposed that this monotypical group had descended from the Ceratocampidae and forms a side branch.

The larva in its third and fourth stages closely resembles that of Arsenura in the same stages, while the larvae of the two genera are similar in the final Stage V, but these resemblances are only analogies, not true affinities.

A pair of locomotive tubercles or claspers on the 2d abdominal segment. — Mr. Joutel has called my attention to a pair of soft tubercles or claspers on the 2d abdominal segment "which is thrust out and seems to be used in walking as though it were a clasper."

On examination of alcoholic specimens of Stages IV and V, I find on the 2d abdominal segment a pair of small tubercles situated in a place exactly corresponding to that of the mid-abdominal legs. Each one is about one-eighth as large as a mid-abdominal leg; about as high as broad at the base, rounded, soft, and giving rise to 6 or 7 black setae of uneven length, but with no definite arrangement; the tubercles are situated in the path of the latero-ventral black line. On the 1st abdominal segment is a minute soft low flattened tubercle situated in the same relative position, but wanting in Stage IV. Are these processes to be compared with the supernumerary legs of Megalopyge? Are they the survivals of primitive abdominal legs?

Pupa. — In shape and size closely similar to that of *Eacles imperialis.* It agrees with the head-characters, i. e., the pupae, eyes, antennae, legs, and wings, differing only in lacking the short stout spines which beset the head and thorax of Eacles, the body being smoother and somewhat polished; the hinder edge of the free segments (abdominal) is smooth, not spinose, as in Eacles. The chief difference consists in the shape of the cremaster, which instead of being narrow, slender, and flattened, is very stout, somewhat conical, much contracted at its base, and with coarse pits, some of which are confluent, forming deep smooth furrows or channels. The cremaster ends in two smooth cylindrical spines. Length 40 mm.; thickness of body 13 mm.

Variation in the terminal spines of the cremaster. — In one example there is but a single median spine at the end of the cremaster, with no vestige of its mate, the spine being central.

When one comes to the moth one would hesitate at classifying Brahmaea with the Ceratocampidae or the Saturnians; its general appearance forbids this. The wings of the Asiatic species are not falcate, and the mode of coloration of the Brahmaeidae is marked by the extraordinary development of undulating lines or bars, which remind one of the geometrid *Scotosia undulata.* Evidently its style of protective coloration, the green, black and gray tints and lines, enable it while resting on the bark of a lichen-covered tree to elude observation.

The venation (♂ and ♀), however, while presenting some important Ceratocampid characters, indicates that Brahmaea should be assigned to an independent family. The first subcostal vein (III_1) is very short,

arising very near the apex of the wing, far beyond the origin of the 3d subcostal (III_3). The 2d median (IV_2) forms an independent vein, as in Ceratocampidae. The discal cell is very small, and the discocellular veins form a reëntering angle. In the hind wing the discal cell is remarkably short, not much longer than wide. The subcostal vein (II), instead of being remote from the subcostal as in all Ceratocampidae, is very close to the subcostal, nearly touching it a little beyond the discocellulars.

The ♂ genital armature is of the Ceratocampid type; the suranal plate being large, broad, slightly bilobed at the end, while the claspers are very broad, rounded at the end, and not mucronate.

While *B. certhia* is regarded as the type of the genus, it, or any of the Asiatic species, scarcely appears to be the stem-form. For this we shall have to turn to the West African *B. lucina*, in which the fore wings are produced towards the apex which is somewhat falcate, and the markings suggest the South American Arsenura; the apical oval dark spots recall those of that genus.

Although there are certain striking superficial resemblances in the larva and pupa to the Ceratocampidae, the antennae are, however, as in *Bombyx mori* and Lasiocampidae, there being but a single pair of pectinations to a joint. The larva before the first moult is as in *B. mori* and Endromis, the flattened tubercles giving rise to several (6–10) setae. The head is as in *B. mori*, the epicranium short and broad, the clypeus sunken; the suranal plate as in *B. mori* and Lasiocampidae. The Brahmaeidae should be associated in a group for which we propose the name *Symbombycina*, with the families Bombycidae, Endromidae, Lasiocampidae, Liparidae, and Eurypterotidae.

We have, from our studies, been led to infer that the original home of the Brahmaeidae may have been in Africa south of the Sahara region, and that the Asiatic and southeastern species are derived from African forms. They are certainly rather more modified, the wings shorter and broader, and the markings more specialized than in the African *B. lucina*.